What is claimed is:

1. A method of manufacturing a solar cell, comprising:

providing a substrate;

depositing a conductive film on a surface of the substrate, wherein the conductive film includes a plurality of discrete layers of conductive materials;

depositing at least one p-type semiconductor absorber layer on the conductive film, wherein the p-type semiconductor absorber layer includes a copper indium diselenide (CIS) based alloy material;

depositing an n-type semiconductor layer on the p-type semiconductor absorber layer to form a p-n junction; and

depositing a transparent electrically conductive top contact layer on the n-type semiconductor layer.

2. The method of claim 1, wherein the discrete layers of conductive materials comprise:

at least one metallic layer of material selected from one or more groups comprising copper, silver, aluminum, molybdenum, and niobium; and

at least one barrier layer of a transition metal nitride material.

3. The method of claim 2, wherein the barrier layer is selected from one or more groups comprising titanium nitride, zirconium nitride, and hafnium nitride.

4. The method of claim 2, wherein the barrier layer comprises zirconium nitride.

5. The method of claim 1, wherein the discrete layers of conductive materials comprises:

a first layer of copper;

a second layer of silver; and

a plurality of barrier layers each of a transition metal nitride material.

6. The method of claim 1, wherein the discrete layers of conductive materials comprises:

a plurality of metallic layers of material each selected from one or more groups comprising copper, silver, aluminum, molybdenum, and niobium; and

a plurality of barrier layers each of a transition metal nitride material.

7. The method of claim 6, wherein the barrier layers are each selected from one or more groups comprising titanium nitride, zirconium nitride, and hafnium nitride.

8. The method of claim 6, wherein the barrier layers each comprises zirconium nitride.

9. The method of claim 1, wherein the deposition of the n-type semiconductor layer includes RF sputtering from a stoichiometric zinc sulfide target in a planar magnetron configuration.

10. The method of claim 1, further comprising:

depositing a layer of metallic material on the p-type semiconductor absorber layer before the deposition of the n-type semiconductor layer, such that the n-type semiconductor layer is deposited on the layer of metallic material.

11. The method of claim 10, wherein the layer of metallic material comprises zinc.

12. The method of claim 1, wherein the substrate comprises thin metallic foil.

13. The method of claim 12, wherein the thin metallic foil is selected from one or more groups comprising stainless steel, copper, and aluminum.

14. The method of claim 1, wherein the deposition of the p-type semiconductor absorber layer includes:

co-sputtering the CIS material from a pair of conductive targets.

15. The method of claim 14, wherein the pair of conductive targets comprises:

a first target comprising a mixture of copper and selenium; and

a second target comprising a mixture of indium, gallium, and selenium.

16. The method of claim 14, wherein the pair of conductive targets comprises:

a first target comprising a mixture of copper and selenium; and

a second target comprising a mixture of indium, aluminum, and selenium.

17. The method of claim 1, wherein the deposition of the p-type semiconductor absorber layer includes:

reactively AC sputtering material from a pair of identical conductive targets in a sputtering atmosphere comprising argon gas and hydrogen selenide gas.

18. The method of claim 17, wherein the pair of identical conductive targets comprises copper, indium and gallium.

19. The method of claim 17, wherein the pair of identical conductive targets comprises copper, indium and aluminum.

20. A method of manufacturing a solar cell, comprising:

providing a substrate;

depositing a conductive film on a surface of the substrate;

depositing at least one p-type semiconductor absorber layer on the conductive film, wherein the p-type semiconductor absorber layer includes a copper indium diselenide (CIS)

based alloy material, and wherein the deposition of the p-type semiconductor absorber layer includes co-sputtering the CIS material from a pair of conductive targets;

depositing an n-type semiconductor layer on the p-type semiconductor absorber layer to form a p-n junction; and

depositing a transparent electrically conductive top contact layer on the n-type semiconductor layer.

21. The method of claim 20, wherein the pair of conductive targets comprises:

a first target comprising a mixture of copper and selenium; and

a second target comprising a mixture of indium, gallium, and selenium.

22. The method of claim 21, wherein the mixture of copper and selenium comprises about 30% of the copper and 70% of the selenium.

23. The method of claim 21, wherein the mixture of indium, gallium, and selenium comprises less than about 60% of the selenium.

24. The method of claim 20, wherein the pair of conductive targets comprises:

a first target comprising a mixture of copper and selenium; and

a second target comprising a mixture of indium, aluminum, and selenium.

25. The method of claim 24, wherein the mixture of indium, aluminum, and selenium comprises less than about 60% of the selenium.

26. The method of claim 20, wherein the pair of conductive targets are disposed on dual cylindrical rotary magnetrons.

27. The method of claim 20, wherein the co-sputtering of the CIS material further comprises:

adjusting a power ratio between the first target and the second target so that the deposited p-type semiconductor absorber layer is slightly copper deficient.

28. The method of claim 20, wherein the co-sputtering of the CIS material from the pair of conductive targets includes:

co-sputtering the CIS material from two or more pairs of the conductive targets in a sequential manner, wherein the composition of each pair of conductive targets varies relative to the other pairs of conductive targets such that the deposited p-type semiconductor absorber layer has a graded bandgap.

29. The method of claim 20, wherein the conductive film includes a plurality of discrete layers of conductive materials.

30. The method of claim 29, wherein the discrete layers of conductive materials comprise:

at least one metallic layer of material selected from one or more groups comprising copper, silver, aluminum, molybdenum, and niobium; and

at least one barrier layer of a transition metal nitride material.

31. The method of claim 20, wherein the deposition of the n-type semiconductor layer includes RF sputtering from a stoichiometric zinc sulfide target in a planar magnetron configuration.

32. The method of claim 20, further comprising:

depositing a layer of metallic material on the p-type semiconductor absorber layer before the deposition of the n-type semiconductor layer, such that the n-type semiconductor layer is deposited on the layer of metallic material.

33. The method of claim 32, wherein the layer of metallic material comprises zinc.

34. The method of claim 20, wherein the substrate comprises thin metallic foil.

35. The method of claim 34, wherein the thin metallic foil is selected from one or more groups comprising stainless steel, copper, and aluminum.

36. A method of manufacturing a solar cell, comprising:

providing a substrate;

depositing a conductive film on a surface of the substrate;

depositing at least one p-type semiconductor absorber layer on the conductive film, wherein the p-type semiconductor absorber layer includes a copper indium diselenide (CIS) based alloy material, and wherein the deposition of the p-type semiconductor absorber layer includes reactively AC sputtering material from a pair of identical conductive targets in a sputtering atmosphere comprising argon gas and hydrogen selenide gas;

depositing an n-type semiconductor layer on the p-type semiconductor absorber layer to form a p-n junction; and

depositing a transparent electrically conductive top contact layer on the n-type semiconductor layer.

37. The method of claim 36, wherein the pair of identical conductive targets each comprises copper, indium, and gallium.

38. The method of claim 37, wherein each of the conductive targets comprises a ratio of copper atoms to indium plus gallium atoms that is less than one.

39. The method of claim 36, wherein the pair of identical conductive targets comprises copper, indium, and aluminum.

40. The method of claim 39, wherein each of the conductive targets comprises a ratio of copper atoms to indium plus aluminum atoms that is less than one.

41. The method of claim 36, wherein the pair of conductive targets are disposed on dual cylindrical rotary magnetrons.

42. The method of claim 36, wherein the AC sputtering of the material from the pair of conductive targets includes:

reactively AC sputtering material from two or more pairs of the conductive targets in a sequential manner, wherein the composition of each pair of conductive targets varies relative to the other pairs of conductive targets such that the deposited p-type semiconductor absorber layer has a graded bandgap.

43. The method of claim 42, wherein a gallium content of each of the conductive target pairs varies relative to the other pairs of conductive targets such that the deposited p-type semiconductor absorber layer has a graded bandgap.

44. The method of claim 42, wherein an aluminum content of each of the conductive target pairs varies relative to the other pairs of conductive targets such that the deposited p-type semiconductor absorber layer has a graded bandgap.

45. The method of claim 36, wherein the conductive film includes a plurality of discrete layers of conductive materials.

46. The method of claim 45, wherein the discrete layers of conductive materials comprise:

at least one metallic layer of material selected from one or more groups comprising copper, silver, aluminum, molybdenum, and niobium; and

at least one barrier layer of a transition metal nitride material.

47. The method of claim 36, wherein the deposition of the n-type semiconductor layer includes RF sputtering from a stoichiometric zinc sulfide target in a planar magnetron configuration.

48. The method of claim 36, further comprising:

depositing a layer of metallic material on the p-type semiconductor absorber layer before the deposition of the n-type semiconductor layer, such that the n-type semiconductor layer is deposited on the layer of metallic material.

49. The method of claim 48, wherein the layer of metallic material comprises zinc.

50. The method of claim 36, wherein the substrate comprises thin metallic foil.

51. The method of claim 50, wherein the thin metallic foil is selected from one or more groups comprising stainless steel, copper, and aluminum.

52. A solar cell, comprising:

a substrate;

a conductive film disposed on a surface of the substrate, wherein the conductive film includes a plurality of discrete layers of conductive materials;

at least one p-type semiconductor absorber layer disposed on the conductive film, wherein the p-type semiconductor absorber layer includes a copper indium diselenide (CIS) based alloy material;

an n-type semiconductor layer disposed on the p-type semiconductor absorber layer, wherein the p-type semiconductor absorber layer and the n-type semiconductor layer form a p-n junction; and

a transparent electrically conductive top contact layer on the n-type semiconductor layer.

53. The solar cell of claim 52, wherein the discrete layers of conductive materials comprise:

at least one metallic layer of material selected from one or more groups comprising copper, silver, aluminum, molybdenum, and niobium; and

at least one barrier layer of a transition metal nitride material.

54. The solar cell of claim 53, wherein the barrier layer is selected from one or more groups comprising titanium nitride, zirconium nitride, and hafnium nitride.

55. The solar cell of claim 53, wherein the barrier layer comprises zirconium nitride.

56. The solar cell of claim 52, wherein the discrete layers of conductive materials comprise:

a first layer of copper;

a second layer of silver; and

a plurality of barrier layers each of a transition metal nitride material.

57. The solar cell of claim 52, wherein the discrete layers of conductive materials comprise:

a plurality of metallic layers of material each selected from one or more groups comprising copper, silver, aluminum, molybdenum, and niobium; and

a plurality of barrier layers each of a transition metal nitride material.

58. The solar cell of claim 57, wherein the barrier layers are each selected from one or more groups comprising titanium nitride, zirconium nitride, and hafnium nitride.

59. The solar cell of claim 57, wherein the barrier layers each comprises zirconium nitride.

60. The solar cell of claim 52, further comprising:

a layer of metallic material disposed between the p-type semiconductor absorber layer and the n-type semiconductor layer.

61. The solar cell of claim 60, wherein the layer of metallic material comprises zinc.

62. The solar cell of claim 52, wherein the substrate comprises thin metallic foil.

63. The solar cell of claim 62, wherein the thin metallic foil is selected from one or more groups comprising stainless steel, copper, and aluminum.

64. The solar cell of claim 52, wherein the p-type semiconductor absorber layer has a graded bandgap.

65. A vacuum sputtering apparatus, comprising:

an input module for paying out substrate material from a roll of the substrate material;

at least one process module for receiving the substrate material from the input module, wherein the process module includes:

a rotatable coating drum around which the substrate material extends,

a heater array for heating the coating drum, and

one or more sputtering magnetrons each having a magnetron housing and a plurality of conductive sputtering targets disposed in the magnetron housing and facing the coating drum for sputtering material onto the substrate material;

an output module for receiving the substrate material from the process module.

66. The vacuum sputtering apparatus of claim 65, wherein the at least one process module includes a plurality of the process modules for sequentially receiving the substrate material.

67. The vacuum sputtering apparatus of claim 66, wherein each of the process modules includes a housing for containing the coating drum, the heater array and the one or more sputtering magnetrons, and wherein each housing includes a pair of slit valves with narrow low conductance isolation slots through which the substrate material passes.

68. The vacuum sputtering apparatus of claim 67, further comprising:

pumping means for each of the process modules to evacuate atmosphere from the module housings and to enable a sustained flow of sputtering gases from the sputtering magnetrons.

69. The vacuum sputtering apparatus of claim 65, wherein the one or more sputtering magnetrons includes a plurality of the sputtering magnetrons for sequentially receiving and sputtering material on the substrate material.

70. The vacuum sputtering apparatus of claim 69, wherein the magnetron housings define process regions and provide gas separation between the process regions.

71. The vacuum sputtering apparatus of claim 69, wherein at least one of the magnetron housings provides a uniform electrical environment for an RF sputtering magnetron.

72. The vacuum sputtering apparatus of claim 65, wherein for each of the sputtering magnetrons, the conductive targets therein are disposed on dual rotary cylinders.

73. The vacuum sputtering apparatus of claim 65, wherein the output module includes a spool around which the substrate material is wound.

74. The vacuum sputtering apparatus of claim 65, wherein the substrate material is selected from one or more groups comprising stainless steel, copper, aluminum, and polyimide.

75. The vacuum sputtering apparatus of claim 65, wherein the input module further comprises:

means for splicing the substrate material.

76. The vacuum sputtering apparatus of claim 65, wherein the input module further comprises:

a heater array for pre-heating the substrate material.

77. The vacuum sputtering apparatus of claim 65, wherein the input module further comprises:

one or more devices for sputter cleaning a surface of the substrate material.

78. The vacuum sputtering apparatus of claim 65, wherein the heater array includes a plurality of high temperature quartz lamps.

79. The vacuum sputtering apparatus of claim 65, wherein the output module comprises at least one sputtering magnetron for depositing a layer of solder on a back surface of the substrate material.

80. The vacuum sputtering apparatus of claim 65, wherein the output module comprises means for splicing the substrate material.